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Research Article

# *Primulina nanlingensis* (Gesneriaceae), a new species from the Limestone Karst of Guangdong, China

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## Abstract

*Primulina nanlingensis*, a new species of Gesneriaceae from the Karst of Guangdong, China, is described and illustrated. This species is morphologically similar to *P. versicolor*, but can be distinguished by its larger crenate-margined leaves, fewer flowers per cyme and overall cyme number, ovate-lanceolate bracts with shallow serrations, calyx lobes with 1–3 teeth per side, stamens densely glandular at base and tip and pistil densely glandular-puberulent. It also resembles *P. pengii*, but has significant differences in its longer corolla, pale yellow corolla colour and ovate-lanceolate bracts. Phylogenetic analyses with ITS and *trn*L-F sequences revealed that *P. nanlingensis* is sister to *P. versicolor* and *P. pengii*, but isolated from its morphological relatives. The phylogenetic and morphological relationships with similar species are discussed, including detailed descriptions, photographs and distribution information. According to the IUCN Red List Criteria, the new species is assessed as Near Threatened [NT].

**Key words:** Gesneriaceae, limestone flora, morphology, phylogeny, taxonomy

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## Introduction

The genus *Primulina* Hance (1883) was initially monotypic, with its type specimen collected from the Lianjiang River Basin in northern Guangdong, China. The second species, *P. guangxiensis* Yan Liu & W.B.Xu, was described in 2011, based solely on morphological characteristics (Liu et al. 2011). Drawing upon molecular and morphological evidence, *Primulina* underwent subsequent revision and expansion, resulting in the identification of 123 species and eight varieties (Wang et al. 2011; Weber et al. 2011). The revision included numerous species from *Chirita* sect. *Gibbosaccus*, two species from *Wentsaiboea* D.Fang & D.H.Qin and *Chiritopsis* W.T.Wang which were consolidated into *Primulina* (Zhou et al. 2016; Xu et al. 2023). Species within the genus *Primulina* are perennial herbs distinguished by their rhizomatous stems, fleshy opposite leaves, corolla with an infundibuliform tube and 2-lipped lobe, two stamens with coherent anthers and

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a characteristic chiritoid stigma (Wang et al. 2011; Yang et al. 2023). As of February 2025, the genus *Primulina* has 244 accepted species, thereby constituting the largest genus in the Chinese Gesneriaceae (Chen et al. 2024; GRC 2025).

Typically residing in the sheltered and moist conditions of karst formations, such as caves and similar microhabitats (Xu et al. 2021), these species are predominantly restricted to limestone niches in southern and south-western China, as well as northern Vietnam (Kang et al. 2014; Li et al. 2019). Globally, the genus includes over 170 species that are endemic to karst regions (Xu et al. 2021; Pan et al. 2022). Guangdong Province is home to 114 species of Gesneriaceae, with a significant proportion of 48 species belonging to *Primulina* (Song et al. 2023). Since 2017, four new species of *Primulina* have been described in Guangdong Province, these being *P. effusa* F.Wen & B.Pan, *P. anisocymosa* F.Wen, Xin Hong & Z.J.Qiu, *P. huangjiniana* W.B.Liao, Q.Fan & C.Y.Huang and *P. liangwaniae* B.M.Wang & Y.H.Tong (Pan et al. 2017; Hong et al. 2019; Huang et al. 2020; Tong et al. 2023).

During a botanical survey conducted in 2024 within the Shimentai Nature Reserve, an unidentified species of *Primulina* was discovered on two limestone hills. The species was subsequently introduced and cultivated in the greenhouses of the South China Botanical Garden, Chinese Academy of Sciences. From April to June of 2024, the plant exhibited continuous flowering with beautiful pale yellow flowers. After rigorous comparison of this material with herbarium specimens and consultation of relevant references and monographs (Guo et al. 2015; Pan et al. 2016), we confirmed that it represents a new species of *Primulina*, which we describe in this study. Phylogenetic analysis, utilising ITS and *trn*L-F sequences, confirmed its position within the genus.

## Material and methods

### Morphological observation

The material of this new species was collected during a botanical survey conducted at Shimentai Nature Reserve, Yingde City, Guangdong Province. The species was cultivated for further morphological study at the South China Botanical Garden, Chinese Academy of Sciences. Morphological assessments of the new species were carried out using herbarium specimens, with measurements taken from fresh samples. Comparative morphology was conducted with morphologically similar species, utilising both living plants and specimens from institutions such as IBSC, KUN, PE and IBK, as well as digital images from JSTOR Global Plants (http://plants.jstor.org/). Indumentum characteristics were examined by an Olympus-SZ61 stereomicroscope and Olympus-BX43 optical microscope, with photographic documentation accomplished using a Nikon D810 camera.

### Molecular sampling

We collected one individual from each of the two natural populations within the protected area and dried the fresh leaf samples using silica gel. Genomic DNA was extracted from the dried leaves using a modified CTAB protocol (Doyle and Doyle 1987). Based on recent phylogenetic studies (Pan et al. 2022;

Yang et al. 2023; Chen et al. 2024), we retrieved ITS and *trn*L-F sequences for 124 *Primulina* species from GenBank to determine the phylogenetic position of the new species. *Petrocodon ainsliifolius* W.H.Chen & Y.M.Shui and *Petrocodon hancei* (Hemsl.) A.Weber & Mich.Möller were selected as outgroup taxa for the analysis (Chen et al. 2024). Corresponding GenBank accession numbers are presented in Table 1.

## Phylogenetic analyses

We constructed Maximum Likelihood (ML) and Bayesian Inference (BI) phylogenetic trees for *Primulina nanlingensis* and 124 *Primulina* species using ITS and *trn*L-F sequences with PhyloSuite v.1.2.2 (Zhang et al. 2020). Sequences were aligned using MAFFT v.7.471 (Katoh et al. 2019) in PhyloSuite v.1.2.3 and refined with Gblocks 0.91b (Talavera and Castresana 2007), prior to their combination. The optimal nucleotide substitution model was determined using ModelFinder (Kalyaanamoorthy et al. 2017) in PhyloSuite v.1.2.3. The ML tree was built using IQ-tree v.1.6.12 (Nguyen et al. 2015) with the TN+F+R3 model and 5000 bootstrap replicates. The BI tree was constructed using MrBayes v.3.2.6 (Ronquist et al. 2012) with the HKY+F+I+G4 model, running two chains for 3,000,000 generations and sampling every 1000 generations. Both models were selected, based on the Bayesian Information Criterion (BIC). Finally, tree visualisation was performed using ITOL v.7 (https://itol.embl.de/).

**Table 1.** Species names and GenBank accession numbers of ITS and *trn*L-F DNA sequences used for analysis.

| Species | ITS | *trn*L-F | Species | ITS | *trn*L-F |
|---|---|---|---|---|---|
| *Petrocodon ainsliifolius* | KF202291 | KF202298 | *Primulina lunglinensis* var. *amblyosepala* | MK747105 | MK746281 |
| *Petrocodon hancei* | KY796057 | KY796059 | *Primulina lungzhouensis* | KY394931 | KY393525 |
| *Primulina alutacea* | KY394847 | KY393441 | *Primulina lutea* | JX506921 | JX506813 |
| *Primulina argentea* | KY394848 | KY393442 | *Primulina lutvittata* | MK369978 | MK369993 |
| *Primulina baishouensis* | KY394849 | KY393443 | *Primulina mabaensis* | KY394937 | KY393531 |
| *Primulina balansae* | MK747141 | MK746274 | *Primulina macrodonta* | JX506923 | JX506815 |
| *Primulina beiliuensis* | KY394850 | KY393444 | *Primulina maculata* | KU220604 | KU220609 |
| *Primulina beiliuensis* var. *fimbribracteata* | KY394851 | KY393445 | *Primulina malipoensis* | MK747123 | MK746240 |
| *Primulina bicolor* | KY394852 | KY393446 | *Primulina medica* | KY394940 | KY393534 |
| *Primulina bipinnatifida* | KY394853 | KY393447 | *Primulina melanofilamenta* | MK747158 | MK746277 |
| *Primulina brachytricha* var. *magnibracteata* | MK369979 | MK369994 | *Primulina minor* | MK747160 | MK746290 |
| *Primulina carinata* | KY394858 | KY393452 | *Primulina minutimaculata* | KY394941 | KY393535 |
| *Primulina cataractarum* | MW900263 | MW960358 | *Primulina moi* | KF498115 | KY393536 |
| *Primulina chizhouensis* | KY394860 | KY393454 | *Primulina mollifolia* | KY394943 | KY393537 |
| *Primulina confertiflora* | MK747101 | MK746253 | *Primulina nandanensis* | KY394947.1 | KY393541 |
| *Primulina cordata* | KC190200 | KC190207 | *Primulina nanlingensis*_YD1 | PQ740297 | PQ759014 |
| *Primulina cordistigma* | MK747118 | MK746251 | *Primulina nanlingensis*_YD2 | PQ740298 | PQ759015 |
| *Primulina crassirhizoma* | KY394864 | KY393458 | *Primulina ningmingensis* | KY394949 | KY393543 |
| *Primulina crassituba* | MK747147 | MK746230 | *Primulina obtusidentata* | KF498096 | KY393544 |

| Species | ITS | *trn*L-F | Species | ITS | *trn*L-F |
|---|---|---|---|---|---|
| *Primulina curvituba* | MK747137 | MK746242 | *Primulina ophiopogoides* | KF498062 | KY393545 |
| *Primulina danxiaensis* | JX506886 | JX506778 | *Primulina orthandra* | MK747128 | MK746286 |
| *Primulina depressa* | KY394869 | KY393463 | *Primulina pengii* | KU220603 | KU220610 |
| *Primulina diffusa* | KY394871 | KY393465 | *Primulina petrocosmeoides* | KY394953 | KY393547 |
| *Primulina dongguanica* | KY394872 | KY393466 | *Primulina pinnatifida* | KY394954 | KY393548 |
| *Primulina dryas* | KY394875 | KY393469 | *Primulina polycephala* | KY394955 | KY393549 |
| *Primulina eburnea* | JX506891 | JX506783 | *Primulina porphyrea* | KU173793 | KU173799 |
| *Primulina efusa* | MK369976 | MK369991 | *Primulina pseudoeburnea* | KY394958 | KY393552 |
| *Primulina fengkaiensis* | MK369975 | MK369990 | *Primulina pseudoglandulosa* | KF498138 | KY393482 |
| *Primulina fengshanensis* | MK369970 | MK369985 | *Primulina pseudoheterotricha* | JX506933 | JX506824 |
| *Primulina fimbrisepala* | JX506894 | JX506786 | *Primulina pseudolinearifolia* | MK747140 | MK746280 |
| *Primulina fimbrisepala* var. *mollis* | JX506895 | JX506787 | *Primulina pseudoroseoalba* | KY394959 | KY393553 |
| *Primulina fordii* | MG727881 | MG727878 | *Primulina pungentisepala* | KY394962 | KY393556 |
| *Primulina fordii* var. *dolichotricha* | MK747125 | MK746247 | *Primulina purpurea* | KY394964 | KY393558 |
| *Primulina glandaceistriata* | MK747114 | MK746256 | *Primulina qingyuanensis* | KY394965 | KY393559.1 |
| *Primulina glandulosa* | KY394887 | KY393481 | *Primulina renifolia* | KY394966 | KY393560 |
| *Primulina gongchengensis* | KY394889 | KY393483 | *Primulina roseoalba* | KY394972 | KY393566 |
| *Primulina grandibracteata* | MK747121 | MK746266 | *Primulina rosulata* | KU528874 | KU528884 |
| *Primulina guihaiensis* | KY394893 | KY393487 | *Primulina rubribracteata* | KU173791 | KU173797 |
| *Primulina halongensis* | KY394895 | KY393489 | *Primulina secundiflora* | MK747119 | MK746279 |
| *Primulina hedyotidea* | JX506905 | JX506797 | *Primulina shouchengensis* | KY394980 | KY393574 |
| *Primulina heterochroa* | KY394898 | KY393492 | *Primulina sichuanensis* | MK747162 | MK746264 |
| *Primulina hochiensis* | JX506903 | JX506795 | *Primulina sinovietnamica* | MK369973 | MK369988 |
| *Primulina huaijiensis* | KF498127 | KY393495 | *Primulina spinulosa* | KF498063 | KY393576 |
| *Primulina hunanensis* | KU220602 | KU220608 | *Primulina subulata* | KY395020 | KY393579 |
| *Primulina jiangyongensis* | KY394902 | KY393496 | *Primulina subulata* var. *guilinensis* | KY394967 | KY393561 |
| *Primulina jingxiensis* | KY394903 | KY393497 | *Primulina subulatisepala* | MK747122 | MK746246 |
| *Primulina jiulianshanensis* | OP243287 | OP243283 | *Primulina suichuanensis* | KY395021 | KY393580 |
| *Primulina jiuwanshanica* | MK747116 | MK746260 | *Primulina tabacum* | KY395023 | KY393582 |
| *Primulina juliae* | MG727889 | MG727873 | *Primulina tenuituba* | KY395025 | KY393584 |
| *Primulina langshanica* | KY394907 | KY393501 | *Primulina tsoongii* | KY395029 | KY393588 |
| *Primulina latinervis* | KY394908 | KY393502 | *Primulina verecunda* | KY395031 | KY393590 |
| *Primulina lechangensis* | KY394910 | KY393504 | *Primulina versicolor* | MK747155 | MK746252 |
| *Primulina leeii* | KY394911 | KY393505 | *Primulina vestita* | MK747156 | MK746282 |
| *Primulina lepingensis* | KY394913 | KY393507.1 | *Primulina villosissima* | KY395032 | KY393591 |
| *Primulina lianpingensis* | MH343910 | MH344542 | *Primulina wenii* | MK747148 | MK746284 |
| *Primulina lijiangensis* | KY394919 | KY393513 | *Primulina wentsaii* | KY395033 | KY393592 |
| *Primulina linearicalyx* | MH032854 | MH032841 | *Primulina wuae* | MK747159 | MK746265 |
| *Primulina linearifolia* | KY394921 | KY393515 | *Primulina xiziae* | KY395038 | KY393597 |
| *Primulina longgangensis* | JX506916 | JX506808 | *Primulina yangchunensis* | KY395039 | KY393598 |
| *Primulina longicalyx* | KY394927 | KY393521 | *Primulina yangshanensis* | KY395040 | KY393599 |
| *Primulina longii* | JX506917 | JX506809 | *Primulina yangshuoensis* | KY395042 | KY393601 |
| *Primulina longnanensis* | OP243286 | OP243282 | *Primulina yingdeensis* | KU528876 | KU528886 |
| *Primulina longzhouensis* | JX506918 | JX506810 | *Primulina yungfuensis* | JX506957 | JX506848 |
| *Primulina lunglinensis* | KY394930 | KY393524 | *Primulina zhoui* | MK747104 | MK746222 |

## Result

### Molecular phylogenetic studies

The ITS matrix, consisting of 128 sequences with an aligned length of 952 base pairs (bp), contained 52.5% variable sites and 34.5% informative sites. Similarly, the *trn*L-F matrix had an aligned length of 1027 bp, with 20.8% variable sites and 9.2% informative sites. Additionally, the combined ITS and *trn*L-F matrix had a total aligned length of 1689 bp and featured 38.8% variable sites and 24% informative sites. The two populations of the new species from Shimentai National Nature Reserve form a monophyletic group (BS = 100%, PP = 1.00), where BS stands for bootstrap support and PP stands for posterior probability. They also form a sister clade with *P. versicolor* and *P. pengii* (BS = 100%, PP = 1.00). All three form a strongly-supported clade with *P. alutacea*, *P. suichuanensis* and *P. polycephala* (Fig. 1).

### Taxonomic treatment

***Primulina nanlingensis*** **J.C.Luo & H.F.Chen, sp. nov.**
urn:lsid:ipni.org:names:77359322-1
Figs 2, 3

**Type.** China • Guangdong Province, Yingde City, Shimentai National Nature Reserve, 23°28'N, 113°05'E, 620 m elev., growing on top of a cliff on a limestone hill, 7 May 2024 (fl.), *J.C. Luo & H.F. Chen LJC00501* (holotype: IBSC; isotypes: IBSC).

**Diagnosis.** The new species is similar to *Primulina versicolor* F.Wen, B.Pan & B.M.Wang in terms of flower shape and corolla colour, but easily distinguished from the larger leaf blades (10–21 × 7–19 cm vs. 8–18 × 6.5–16.5 cm) with a crenate margin (vs. entire); notably lower number of flowers (3–4 cymes, 4–8 flowered vs. 4–8 cymes, 4–24 flowered or more); bracts ovate-lanceolate (vs. broadly oval or suborbicular), with shallowly serrate margins above the middle (vs. entire margins); calyx lobes densely glandular on both surfaces (vs. outside glandular-pubescent inside nearly glabrous) and with 1–3 inconspicuous teeth each side (vs. 3–5-serrate); longer pistil (3.2–3.5 cm vs. 2.5–2.8 cm) and glandular-puberulent (vs. puberulent); filaments white (vs. pale yellow) with densely glandular at base and tip, sparser mid-section (vs. only upper half sparsely glandular-puberulent). Additionally, while the leaf morphology of this new species resembles that of *P. pengii* W.B.Xu & K.F.Chung, it differs in having a longer corolla length (4.2–5.2 cm vs. 2.8–3.6 cm), pale yellow corollas (vs. white) and ovate-lanceolate bracts with slightly serrate edges above the middle (vs. cordate bracts with entire margins).

**Description.** Herbs, perennial rhizome subterete, 5–8 cm × 1.5–2.5 cm, internodes indistinct. Leaves 6–8, opposite at top of rhizome; blade green, succulent to thickly chartaceous, ovate or broadly ovate to elliptic, 10–21 × 7–19 cm, apex obtuse or subacute, margin crenate, base slightly oblique or symmetrical, leaf surface and petiole densely pubescent, abaxial surface densely villous and the veins on the abaxial surface densely pubescent; lateral veins 4–6-nerved on each side; petiole cross section sub-semicircular or compressed, 2.5–9.5 cm × 0.8–1.5 cm. Cymes axillary, 3–4, 4–8 flowers per cyme; bracts 2 opposite, ovate-lanceolate, 4.1–4.4 cm × 2.2–2.4 cm, outer side is shallowly serrate, apex

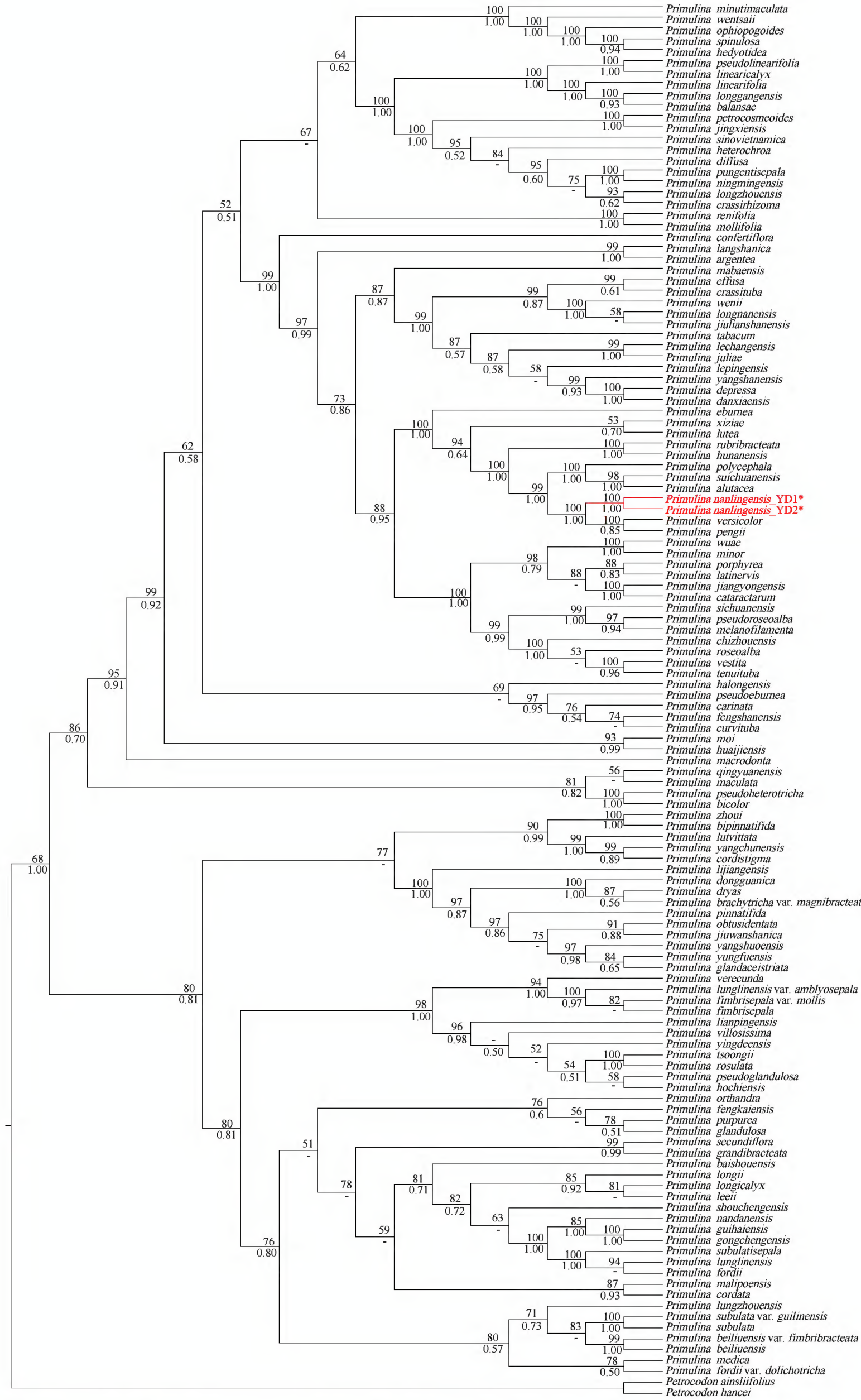


**Figure 1.** Phylogenetic tree of *Primulina* generated using Maximum Likelihood (ML) analysis and Bayesian Inference (BI) of the combined ITS and *trn*L-F sequences. Numbers on branches indicate bootstrap support (≥ 50%) from ML and posterior probabilities (≥ 0.50, rounded to two decimal places) from Bayesian Inference (BI) analyses, while values (< 50% / 0.50) below this threshold are represented by a dash (–). * indicates the new species.

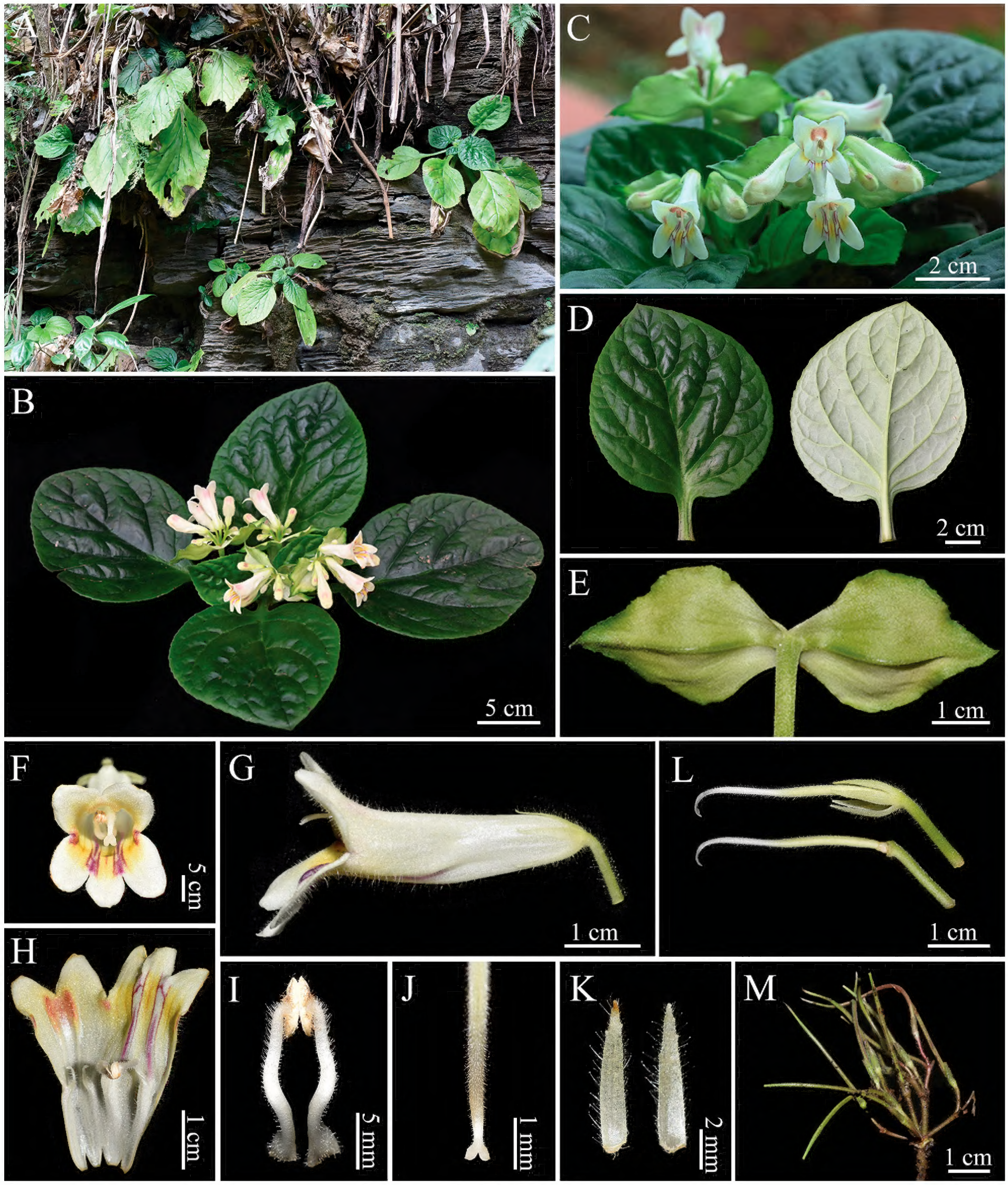


**Figure 2.** *Primulina nanlingensis* J.C.Luo & H.F.Chen **A** plants in natural habitat **B** habit in flowering **C** cyme and frontal view of corolla **D** the adaxial and abaxial surface of leaf blades **E** outside surface of bracts **F** frontal view of corolla **G** side view of corolla **H** opened corolla showing stamens, staminodes and colour **I** stamens **J** stigma **K** outside and inside surface of calyx lobes **L** pistil with calyx lobes and pistil without calyx lobes **M** infructescence.

acuminate, outside pubescent, inside sparsely pubescent; peduncle 5–12.5 cm long, 4–6 mm across, densely pubescent; pedicel 1.2–2.8 cm long, glandular-puberulent. Calyx 5-lobed nearly to the base, 8–15 mm × 1.6–2.5 mm, lanceolate, light green, both surfaces densely glandular-puberulent, with 1–3 inconspicuous

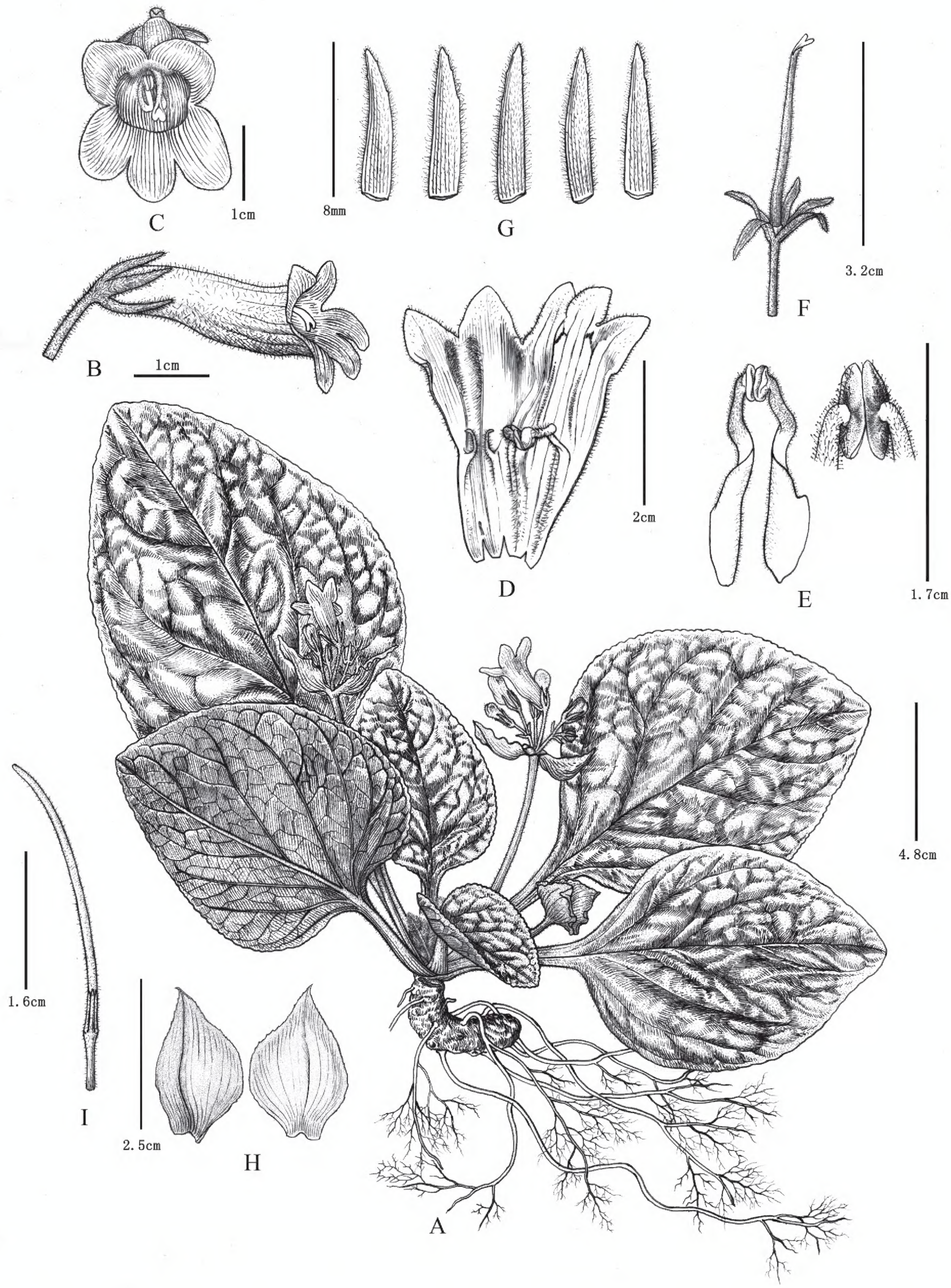


**Figure 3.** *Primulina nanlingensis* J.C.Luo & H.F.Chen **A** habit **B** side view of corolla **C** frontal view of corolla **D** opened corolla **E** stamens **F** pistil with calyx lobes **G** outside surface of calyx lobes **H** outside surface of bracts **I** capsule. Drawn by Mrs. Yunxiao Liu based on *J.C. Luo & H.F. Chen LJC00501*.

teeth on each side. Corolla 4.2–5.2 cm long, pale yellow, throat dark yellow with 2 pale purple stripes, with 3 patches at the sinuses of the 2 upper lip lobes, patches light brown outside and dark purple inside, sometimes the dark purple patches absent and these patches are glandular, outside densely glandular-pubescent; tube infundibuliform, 3.2–3.8 cm long, orifice ca. 1.3 cm in diameter; limb distinctly 2-lipped, adaxial lip 2-lobed bifid to over the middle, lobes oblong, 5–7 mm × ca. 6 mm; abaxial lip 3-lobed to one-third from the top, lobes oblong, 4–6 mm × ca. 4 mm. Stamens 2, adnate to 1.3–1.5 cm above the base of the corolla base; anthers elliptic, 2.5–3 mm long, densely glandular; filaments ca. 15 mm long, white, with the base and upper part sparsely covered with glandular-puberulent; staminodes 3, two lateral ones adnate to ca. 1.3 cm above the corolla base, ca. 7 mm long, densely glandular-pubescent, apex bent, the central one adnate to ca. 3 mm above the base of corolla base, ca. 2 mm long, glabrous; disc annular, ca. 1 mm high, yellow, glabrous. Pistil 3.2–3.5 cm long; ovary linear, ca. 1.8–2.2 cm long, densely glandular-puberulent; style 0.8–1.2 cm long, sparse glandular-puberulent. Stigmas 2-lobed, 2.8–3.6 mm long, shallowly lobed, lobes ca. 1 mm long. Capsule green, mature dark brown, 3.2–4.5 cm × 1.5–2.2 mm, with persistent calyx lobes at base, densely white-villous and pubescent.

**Phenology.** Flowering from late April to early June, fruiting from June to August.

**Distribution and ecology.** *Primulina nanlingensis* is known only from two separate limestone hills in the Shimentai National Nature Reserve, Yingde City, Guangdong Province, China. Companion species were calcareous herbs such as *Selaginella effusa* Alston, *S. delicatula* (Desv.) Alston., *Pilea peltata* Hance and *Ficus sarmentosa* var. *henryi* (King ex Oliv.) Corner etc.

**Etymology.** The species epithet refers to the type locality, the Nanling Mountains.

**Vernacular name.** 南岭报春苣苔 (Chinese name); Nán Lǐng Bào Chūn Jù Tái (Chinese pronunciation).

**Provisional conservation status.** At present, only two populations of *Primulina nanlingensis* have been discovered on limestone hills in the Shimentai National Nature Reserve, where a substantial area of 35 $km^2$ has been identified as suitable habitat for the species. The two naturally distributed populations are no more than 10 km apart and each population consists of no more than 100 mature individuals. Currently, the two populations are stable, as the habitat is under protection by the administrators of the scenic area. However, considering the overall low number of individuals across the species populations and the conservation measures in place, it could be provisionally classified as Near Threatened [NT] according to the IUCN Red List Categories and Criteria (IUCN Standards and Petitions Committee 2024).

**Additional specimens examined.** China • Guangdong Province, Yingde City, Shimentai National Nature Reserve, 23°28'N, 113°05'E, 620 m elev., growing on top of a cliff on a limestone hill, 25 May 2024 (fl.), *J.C. Luo & H.F. Chen LJC00502* (IBSC).

## Discussion

The karst regions of southern and south-western China, as well as northern Vietnam, are hotspots for diversity of *Primulina* species, predominantly consisting of endemic species with limited populations confined to isolated sites (Kang et al. 2014; Tong et al. 2020; Wei et al. 2022). The Nanling Mountain

**Table 2.** Comparisons of *Primulina nanlingensis* to *P. versicolor* and *P. pengii*, respectively.

| Part | *P. nanlingensis* | *P. versicolor* | *P. pengii* |
|---|---|---|---|
| Leaf blade | ovate or broadly ovate to elliptic, 10–21 cm × 7–19 cm, margin crenate | broadly oval or nearly cordate, 8–18 cm × 6.5–16.5 cm, margin entire | ovate to broadly ovate, 14–25 cm × 9.5–15 cm, the margin shallowly repand to crenate |
| Cyme | 3–4, 4–8-flowered | 4–8, 4–24-flowered or more | 3–4, 4–12-flowered |
| Bracts | ovate-lanceolate, 4.1–4.4 cm × 2.2–2.4 cm, shallowly serrate above the middle, apex acuminate, outside pubescent, inside sparsely pubescent | broadly oval or suborbicular, 5–5.5 cm × 4.4–5 cm, apex acute, outside densely appressed pubescent, inside nearly glabrous, margin entire | cordate, 2.6–3.2 cm × 2.5–3 cm, the margin entire to shallowly repand, the apex acute, outside pubescent, inside sparsely pubescent |
| Corolla | pale yellow, 4.2–5.2 cm, outside densely glandular-pubescent, inside nearly glabrous; throat dark yellow with 2 pale purple stripes | canary yellow, 3.5–4.2 cm, outside densely glandular-pubescent, inside nearly glabrous; throat dark yellow with 2 brownish-purple stripes | white, 2.8–3.6 cm long, outside glandular pubescent, inside sparsely puberulent, with 2 pale purple stripes |
| Calyx lobes | 8–15 mm × 1.6–2.5 mm, both surfaces densely glandular, with 1–3 inconspicuous teeth each side | 8.5 mm × 2 mm, outside densely glandular-pubescent, inside nearly glabrous, margin 3–5-serrate | 8–10 mm × ca. 2 mm, outside glandular pubescent, inside sparsely pubescent, margin serrulate |
| Stamens | filaments ca. 15 mm long, white, densely glandular at base and tip, sparser mid-section, anthers elliptic, 2.5–3 mm long, densely glandular | filaments ca. 12.5 mm long, pale yellow, glabrous, but the upper half of filament sparsely glandular puberulent, anthers semicircular, 5–6 mm long, glabrous | filaments ca. 14 mm long, white, sparsely puberulent, anthers reniform, ca.4 mm long, puberulent |
| Pistul | 3.2–3.5 cm long, densely glandular-puberulent | 2.5–2.8 cm long, densely puberulent | 2.4–3.1 cm long, densely puberulent |

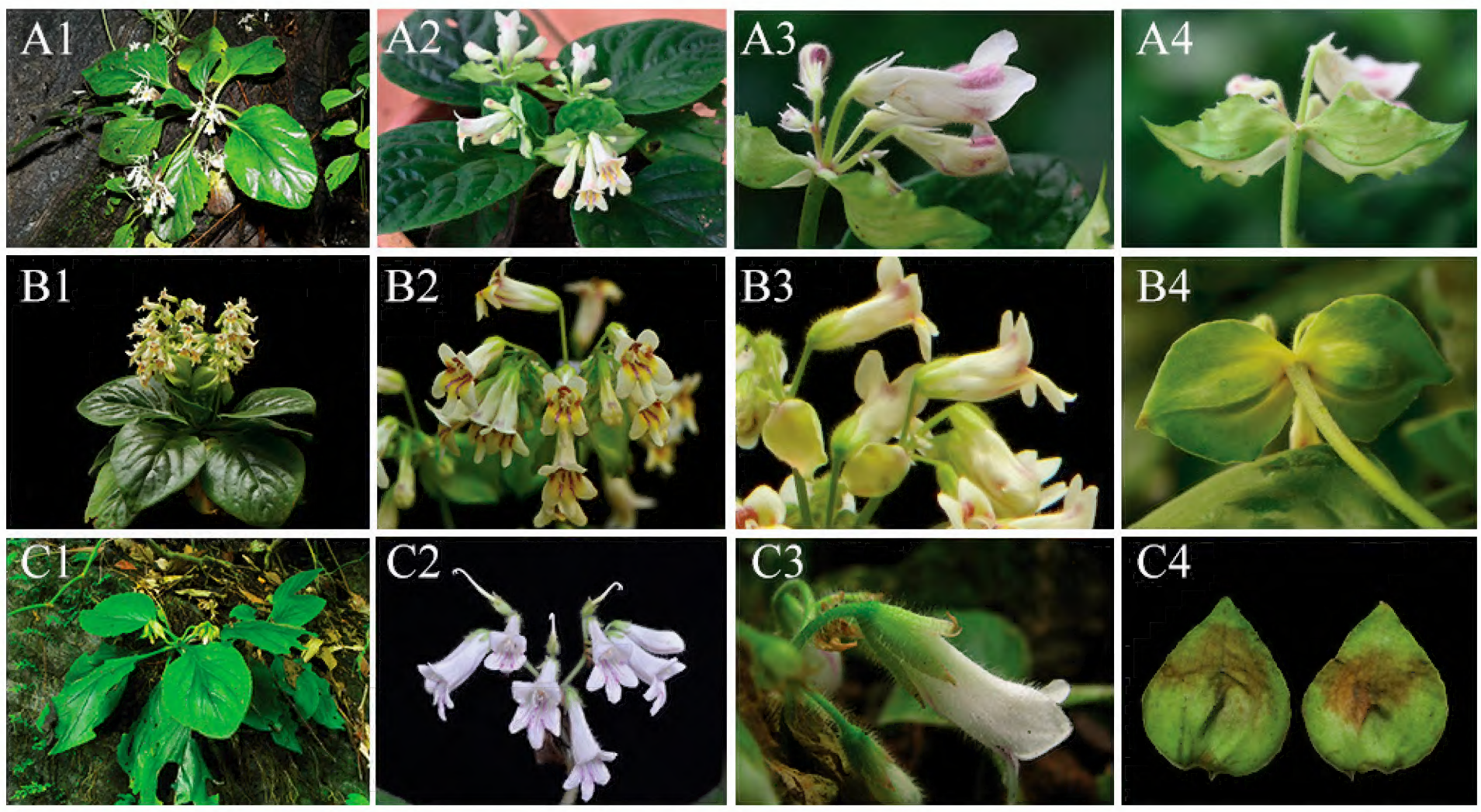


**Figure 4.** Morphological comparison between *Primulina nanlingensis* (**A1–A4**), *P. versicolor* (**B1–B4**, photos by Fang Wen.) and *P. pengii* (**C1–C4**, photos by Weibin Xu). Legends: Leaf blade (**A1, B1, C1**); Cyme (**A2, B2, C2**); Corolla and Calyx lobes (**A3, B3, C3**); Bracts (**A4, B4, C4**).

Range serves as a habitat for *Primulina*, where the complex topography and soil heterogeneity foster a high level of species diversity and endemism (Wang et al. 2017). The type localities for both *P. nanlingensis* and *P. versicolor* are situated within Yingde City, with a distance of over 50 km between them. Furthermore, *P. pengii* is found in Yangshan County, Guangdong Province, which is more than 120 km away from *P. nanlingensis*. Notably, *P. nanlingensis* closely resembles

*P. versicolor* in both flower shape and colour, but differs in several internal floral structures, such as the pistil with glandular-pubescent and stamens densely glandular at the base and tip, sparser in the middle, fewer flowers per cyme and overall cyme number. Phylogenetic analysis shows that they are closely related, yet their morphological differences suggest that *P. nanlingensis* represents a new species. Detailed comparisons of the three species are provided in Table 2 and Fig. 4. Finally, given the small population size and restricted distribution to just two locations, conservation efforts for *P. nanlingensis* are of utmost importance. In all, *P. nanlingensis*, as a newly-discovered species in *Primulina*, not only enhances the plant diversity in Naning Mountain, but also provides valuable insights for further study on the local adaptation in karst regions.

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## Additional information

### Conflict of interest

The authors have declared that no competing interests exist.

### Ethical statement

No ethical statement was reported.

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### Author contributions

Hong-Feng Chen, Yuan-Qiu Li, Jin-Chu Luo: Conceptualisation, Methodology; Hong-Feng Chen, Yuan-Qiu Li, Yang-Jin Zeng, Jin-Chu Luo, Ming-Zhao She: Field investigation, Materials collection; Jin-Chu Luo: Data analyses and visualisation; Jin-Chu Luo: Manuscript writing; Hong-feng Chen, Yuan-Qiu Li, Ya-Li Li, Fa-Guo Wang: Manuscript revision. All authors have read and approved the manuscript.

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### Data availability

All of the data that support the findings of this study are available in the main text.

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